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L. Woolman has a note on the "Oriskany Sandstone in Lycoming County, Pa.," in the *Proc. Acad. Nat. Sci. Philad.*, p. 296, September, 1886.

THE DIPNOAN BRAIN.¹

BY BURT G. WILDER.

THIS paper includes an account of the brain of *Ceratodus* (*Neoceratodus* Gill), substantiated by photographs and preparations of three unusually well-preserved specimens in the Museum of Cornell University; an admission of the writer's own earlier errors in respect to the brains of "fishes," especially in disregarding the membranous portions of the cœlian parietes; a criticism of Huxley's paper in the *Zool. Soc. Proc.*, January 4, 1876 (the later paper of Beauregard does not discuss the *structure* of the brain); a tabular statement of the resemblances and differences between the Dipnoi and other groups, particularly the Plagiostomes and Amphibia; a reiteration of belief (*Am. Assoc. Proc.*, 1875, 189) in the paramount value of cardiac and encephalic characters for the discrimination of more comprehensive groups; a reference to the morphological significance of the *aula* or mesal division of the prosocœle; a list of points requiring further investigation.

The brain of *Ceratodus* agrees with that of *Protopterus* (as described and figured by Fulliquet in the *Recueil Zool. Suisse* for 1886, and as seen in a recent dissection by the writer) in the important point that *the prosencephal consists mainly of a pair of large lobes whose cavities (procœles or "lateral ventricles") are connected only by a comparatively small aula*, as in Amphibia and the higher vertebrates. Unlike *Protopterus*, however, between the dorsal parts of these lobes there is a *long and thick supraplex*, which, through an interruption of the proper nervous parietes for nearly the whole length, sends into each lobe a prolongation covered, like all plexes, by the lining endyma. In mammals,

¹ Abstract of a paper "On the Brain of *Ceratodus*, with Remarks upon Classification and the General Morphology of the Vertebrate Brain," read, by invitation, before the National Academy of Sciences, April 22, 1887.

birds, and reptiles such an interruption for plexal intrusion, when it exists, extends *caudad* from the porta or lateral orifice of the aula, and is known as the *rima* ("great transverse fissure" of anthropotomy). In *Ceratodus* alone, so far as known to the writer, is there a *prerima*,—that is, a rima extending *cephalad* from the margin of the porta. The brain examined by Huxley was evidently ill preserved; the supraplex was mistaken for a *tela vasculosa* (the writer's *aulatela*). Finally, it would appear that the margins of the rima on each side, after the supraplex was pulled out, were supposed to be artificial, so as to lead to the supposition that the dorsal portions of the cavities of the lateral lobes formed a single large "*ventriculus communis*." In the writer's specimens the lobes are separated as high as the plexus by a firm, membranous *quasi-falx*, and the prosencephalic region of the cranial floor presents a distinct mesal ridge, which is absent in *Protopterus*. In *Ceratodus* the olfactory lobes are pedunculated instead of sessile, as in *Protopterus*; but in both genera (and apparently also in *Lepidosiren*) they lie in the plane of the general brain-axis, and the proper cerebral outgrowths are ventral in position instead of dorsal, as in the Amphibia, Reptiles, Birds, and Mammals. Among other features not before recorded of *Ceratodus* is the *precommissure* and a thick *valvula* reaching more than half-way to the floor of the encephalocœle (general cavity of the brain). The conarium is very large and saccular, and closely attached to the supraplex. As stated by Huxley, the tip of the conarium is 'lodged in a distinct depression (the conarial fossa) in the roof of the cranial cavity, and the mesencephal does not present any marked furrow between paired optic lobes. Of the resemblances from which Huxley concludes that, "in its cerebral [encephalic] characters, *Ceratodus* occupies a central place in the class Pisces" [Ichthyopsida, excluding Amphibia], some are trivial, others apply to more than one group, and others are founded upon errors of observation or interpretation. So far as the brain is concerned, *Ceratodus* has no near affinity with the Plagiostomes, much less with the Holocephals, Ganoids, Teleosts or Marsipobranchs. In the writer's opinion, the Dipnoi form a class co-ordinate with the Amphibia, with which, on the whole, they are most nearly allied. The heart needs further study, and the development is unknown.

In a shark, *Scymnus*, as figured by T. J. Parker (*New Zealand Inst. Trans.*, xv. 1882; *Nature*, December 30, 1886), each lateral portion of the prosencephal, between the unpaired part and the olfactory lobe, presents a fusiform and nearly symmetrical dilatation. In 1876 the writer called attention (*Am. Jour. Sci.*, xii. 105) to the fact that in the lamprey the only part which can be regarded as a cerebral hemisphere lies *laterad* of the olfactory lobe (caudad when the paired portions are at a right angle with the meson); also that in most sharks and rays the "hemisphere" projects on the *opposite side* of the olfactory crus, and usually unites with its platetrope (lateral homologue). In Dipnoi the cerebral outgrowth is *ventral*. In either of these directions in which what may be regarded as the special organ of the mind is projected among these low or generalized forms there would seem to be mechanical obstacles to any considerable expansion; but *dorsally* there is opportunity for comparatively unlimited extension, and it is in this direction that the hemispheres begin to develop in the Amphibia and attain such enormous growth in Birds and Mammals. This revolution, so to speak, of the hemisphere about the olfactory axis accords with other considerations which have led Spitzka and the writer independently to consider the prevailing idea that the olfactory lobes are mere appendages of the cerebrum as nearly the reverse of the truth.

EXPLANATION OF FIGURES.

The figures are tracings from photographs, with slight modifications. The proportions and leading features are therefore accurate. There are some points of difference between the two brains, and some conditions which may be artificial; these will be referred to in connection with the several figures. Attention is called to the fact that, to one familiar with the brains of Amphibia, Reptiles, and the lower Mammals, the cephalic portion (prosencephal) of the *Ceratodus* brain looks more natural when held upside-down; this is due to the unusual relative positions of the olfactory tract and the cerebral hemisphere.

The following apply to the three figures: The dotted areas represent cut or artificial surfaces; the heavy line, forming the ental margin of the cut surfaces, represents the *endyma*, which lines the cavities and is reflected over the plexes. The line (usually lighter) which forms the ectal margin of the cut surfaces, and the outline of parts not cut, represents the *pia*, from which vessels are given off to form the plexes. At some places—*e.g.*, the *metaplex*, or membranous roof of the *metacale*, and the dorso-caudal wall of the saccular *conarium*—the parietes consist only, or practically only, of the pia and the endyma; at other places—*e.g.*, the greater part of the *infundibulum*—the nervous constituent of the parietes is very thin. Along the roof of the *mesocale* and the floor of the same region and the parts caudad

of it the double outline indicates the existence of a peculiar, thick, almost cartilaginous, and apparently non-vascular envelope, the nature and relations of which are undetermined. No attempt has been made to show the *arachnoid*. From what has been said it will be understood that the clear areas enclosed by the endyma represent the *encephalocœle*, or cavity of the brain, with its extensions into the *conarium* and *hypophysis*, while the clear areas not so included represent natural, pial surfaces. The *metacœle* and *epicœle* together correspond to what is commonly called "fourth ventricle;" the *mesocœle* to the iter, or cavity of the region of the optic lobes; the *diacœle* to the larger part of the "third ventricle;" the *aula*, which is commonly confounded with the third ventricle, is really the mesal division of the *prosocœle*, or irregular cavity of the prosencephal; its other divisions are the *procœle* ("lateral ventricle") and *rhinocœle* ("olfactory ventricle") on each side.

FIG. 1.

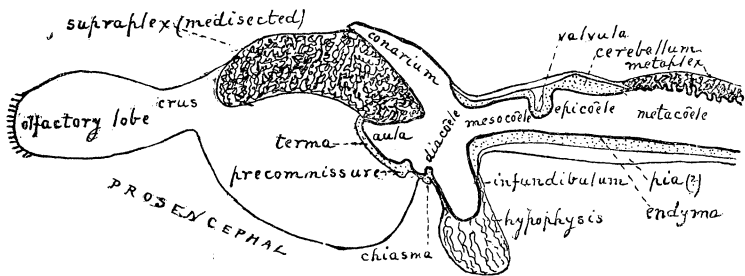


FIG. 1.—Medisection of the brain of No. 425 ($\times 2$). The natural (pial) surfaces are those of the mesal aspect of the olfactory lobe and crus and of the larger part of the "cerebral hemisphere." The supraplex in this specimen is very thick, completely hiding the *prerima*, through which it finds entrance into the *procœles*, as seen in Fig. 2.

FIG. 2.

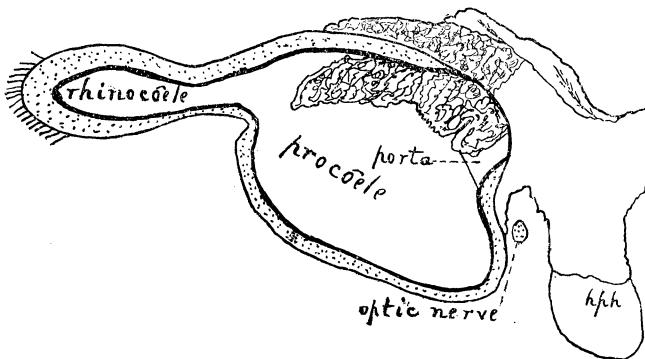
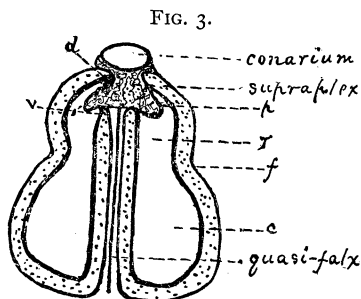


FIG. 2.—Part of the same brain ($\times 2$), the left *prosocœle* exposed so as to show the extent of the plexus after its entrance. The area marked *porta* is the lateral orifice of the *aula*, and is more commonly called "foramen of Monro;" *hph* indicates the hypophysis.

FIG. 3.—Transection of No. 424, just cephalad of the conarium ($\times 3$). In this the plexus is not so thick in the dorso-ventral direction, but its prolongations (covered, like all plexes, by endyma) are bulky, and cause the dorsal and ventral margins of the rima (*d*, *v*) to be far apart. Between the mesal surfaces of the lobes is a line representing the membranous but tough *falx*, the exact relations of which to the plexus are not determined; *c* points to the ventral or true cerebral portion of the procoele; *r* to its dorsal part, which is more directly continuous with the cavity of the olfactory lobe. The lateral furrow

(*f*) may be significant, but may also be the result of alcoholic shrinkage. It does not appear in No. 425.



TERIAS LISA.

(At Ship Island, Gulf of Mexico.)

FRAIL habitant of yonder shore,
 From off the leaf that sheltered thee
 What wondrous craft thy being bore
 Safe through the cyclone of the sea!
 Thy citron-yellow wings are bright,
 And soft the rosy fringe they wear,
 And rays of gloom and silver bright
 Adorn thee, blossom of the air!

The Cassia, on whose silken flower
 Thy fragile life its being fills,
 What hast thou garnered of its dower
 To waft thee where thy spirit wills?
 What dream of flowers of fairer hues,
 Of lights more beautiful than dawn,
 Of winds of balm and honey-dews
 Allured thee ever on and on?

Thou didst but ask, O faëry sprite,
 A blossom cup, the morning beam,
 Companions for thy circling flight,
 And love to share thy rainbow dream!